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Modeling Handover in Satellite Communications

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Abstract

The Handover is one of the key subjects in maintaining the quality of service offered by non-geostationary constellation systems. As the satellite coverage moves according to the satellite motion, the continuity of a call must be maintained from one satellite to another. In case of the Handover fails, the call is dropped, resulting in a quality degradation of service.

In this paper, the performance of several channel assignment strategies for a LEO satellite constellation is evaluated. The FCA and DCA methods are considered where its advantages and disadvantages are highlighted. Moreover, the Handover process implication in the call blocking probability is assessed via simulation. Strategies able to cope with the high number of Handovers, due to the high speed of the satellites, without affecting strongly the capacity of the system are investigated. Simulation models have been developed to implement all the features evaluated in this paper including the mobility model. An analytical description and interpretation of results are also presented.

Keywords: *Handover, satellite constellation, FCA technique, DCA technique*

1. Introduction

Most current research is directed towards the possibility of improved systems of satellite communications. This improvement raises several problems since each network has different characteristics (bandwidth, coverage area, power, standard, *etc.*,). One of the problems is also envisaged that the implementation of a seamless handover without data loss [1-3].

The handover has been studied from several points of view: algorithms, protocol, mechanisms, architectural, *etc.*, [4-6]. The interests of the work take into account several aspects:

- Improving handover (seamless handover, reduce the loss of blocking, improve network utilization, *etc.*,) and QoS. The development handover could then be implemented at various levels of protocol stacks, especially at the network level.
- The decision to handover to the extent that one must know when and at what level the handover should be triggered. The interest is to select the best network based on criteria and conditions that allow the outbreak of handover.
- Mobility with and without consideration of the location of the mobile terminal.

2. Mathematical Modeling

In the following, we consider that the arrival of new calls forms a Poisson process with an average λ. The intensity of the Poisson process services is μ. The arrivals of handover requests form a Poisson process of average λ_h. If a mobile channel in the cell, the call duration (with mean $1 / \mu$) is equal to the time during which the call is in progress without having under gone a forced termination due to failure of the handover.

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If a channel has been allocated to a mobile, it will be released at the end of the call is due to a handover to a neighboring cell. So the channel occupation time is the minimum duration of the call. We denote by:

Pb: probability that a new user finds all channels busy in a cell.

Ph: probability of failure of the handover. Is the probability that a handover call finds all channels occupied on his arrival in the neighboring cell.

3. Allocation Techniques Channels

3.1. Allocation FCA Kind

A number of channels are permanently assigned to each cell. The same set of channels is assigned to another cell at a distance D. The FCA technique implies that each call is served by an available channel belonging to the set of channels assigned to the cell. If there is no channel available, the call is lost. The number of assigned channels is M = S / K where M is the number of K resource and the reuse pattern [7].

3.2. Dynamic Channel Allocation DCA

To solve the problem in the schematic FCA a new strategy was proposed: dynamic allocation of DCA channel. It is different from the previous one so that all channels become available for each cell. Thus in all DCA channels are combined into a "pool" to be allocated to the mobile as appropriate, provided that either satisfies the CIRmin [8-11].

Despite the complexity of implementation of DCA, it has high flexibility and better adaptation to traffic (*i.e.*, distribution channels between the cells in the case of non-uniform traffic). However, it should be noted that this technique is less effective than technical fixes where traffic would be overloaded [12, 13].

4. The Simulation Parameter

Several simulations were done to evaluate the performance of different techniques Handover. Assume that arrivals mobiles in a cell form a Poisson process with an average λ. The arrivals of handover requests form a process fish λ_h average. λ and λ_h are linked together by the following equation:

$$\lambda_h \approx \frac{\mu_{c-\mathrm{dwell}}}{\mu_C}\lambda \quad (1)$$

In our study we consider that the average call duration T_m = 3 minutes and the number of channels S = 20 and the length of the queue of 25, $\boldsymbol{t_{wmax}} = 0.096mn$.

The measured parameters are considered:

- Pb blocking probability of new calls.
- Ph the probability of failure of handover.

5. DCA without Priority

5.1. Organization Chart

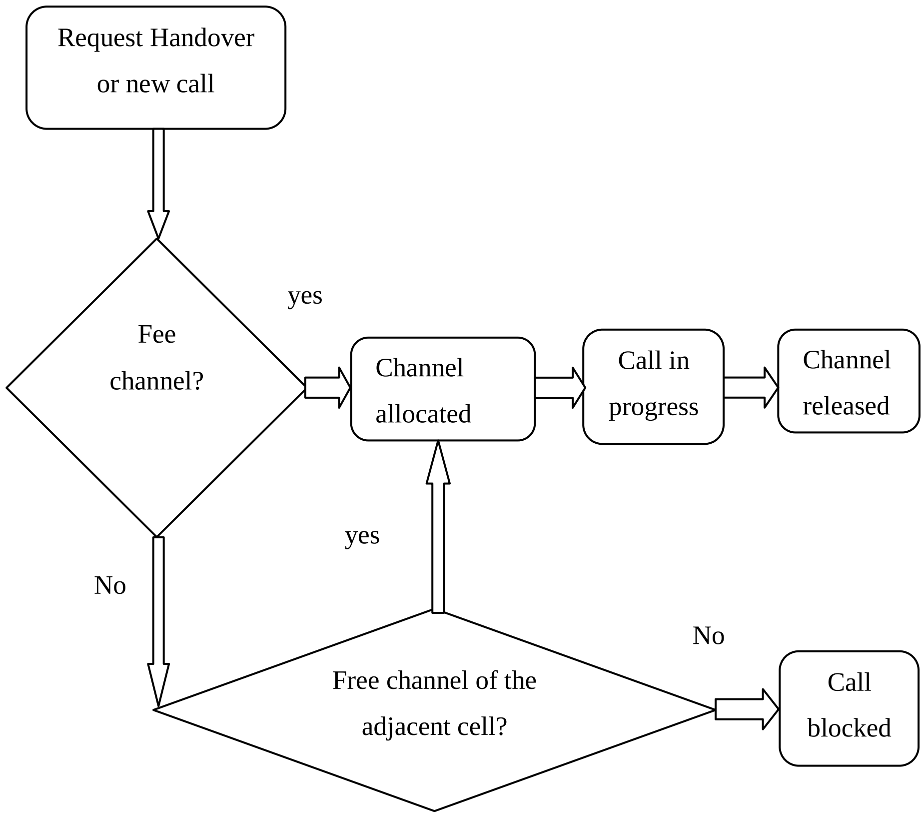


Figure 1. The Organization Chart of DCA Technique without Priority

5.2. The Simulation Results

The curves show that the blocking probability of new calls is equal to the blocking probability of handover because new calls are treated in the same manner as Handovers. Figure 2 shows the blocking probability of new calls and handover based on traffic (Erlang) for the DCA technique.

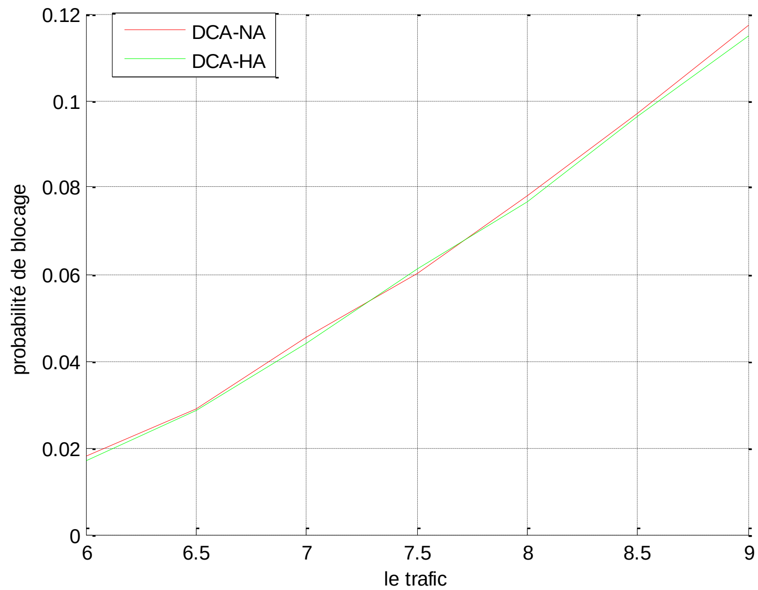


Figure 2. DCA Without Priority Handover

Figure 3 shows the blocking probability of handover and new calls for both technical FCA and DCA without priority.

According to the results we note that the DCA technique reduces the blocking probability of new calls and handovers when compared with the FCA technique.

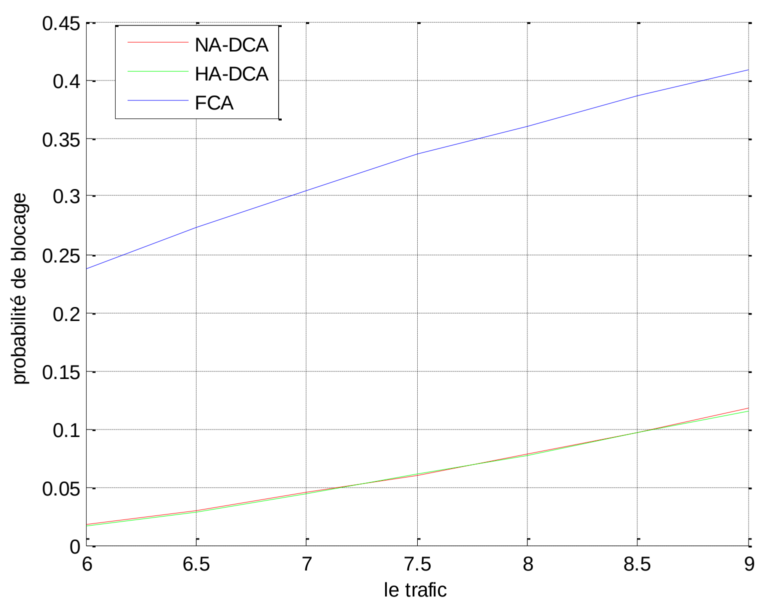


Figure 3. Comparison between FCA and DCA without Priority Handover

6. DCA Priority Handover

6.1. Organization Chart

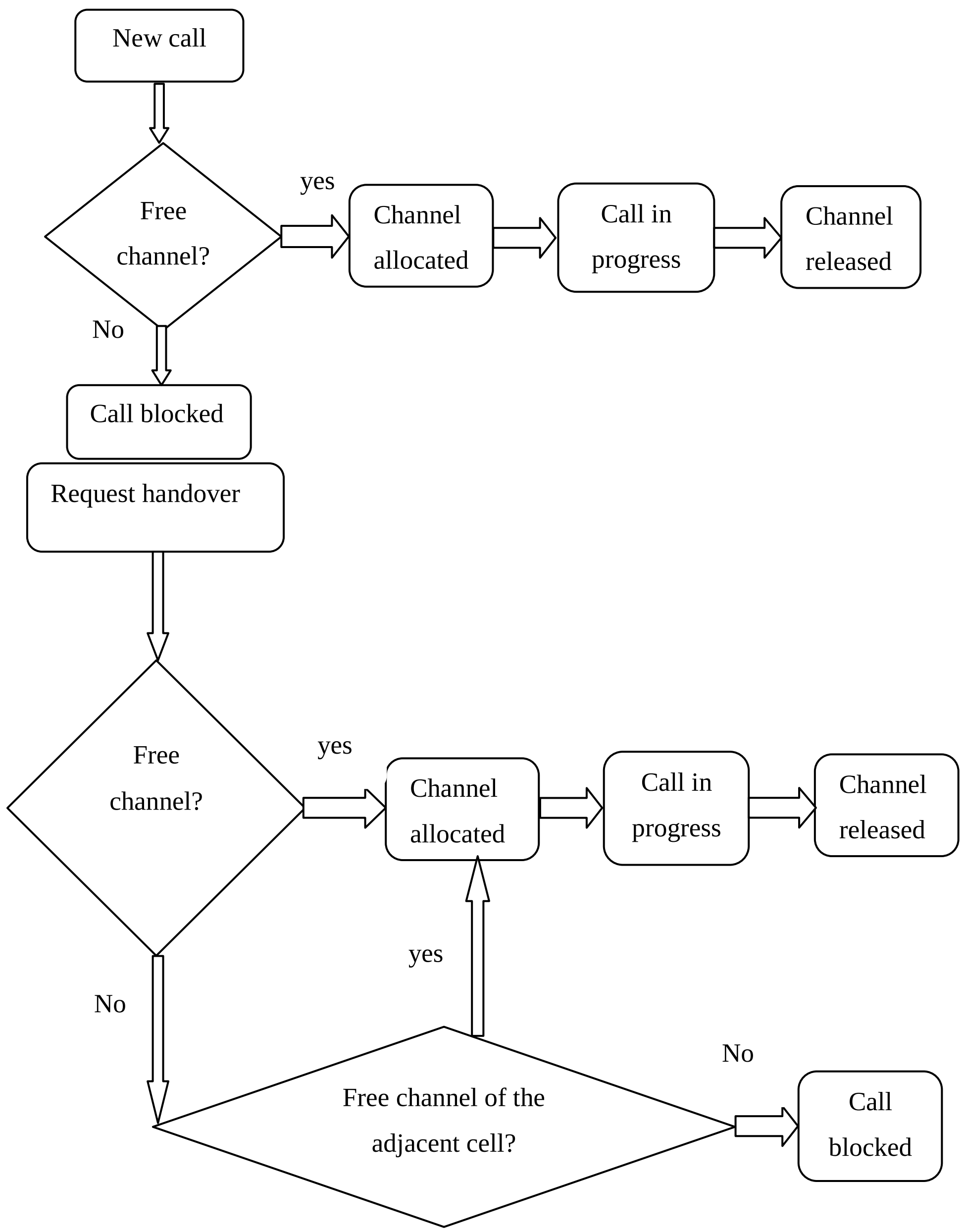


Figure 4. Organization Chart of DCA Technique with Priority Handover

6.2. The Simulation Results

Figure 5 shows the blocking probability of new calls and handover according to traffic for both techniques FCA and DCA with the priority of the handover.

The DCA technique reduces its priority handover blocking probability and increases the blocking probability of new calls when compared with FCA.

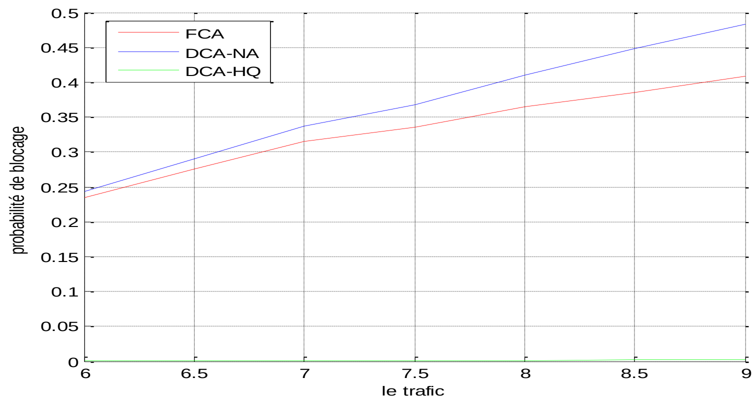
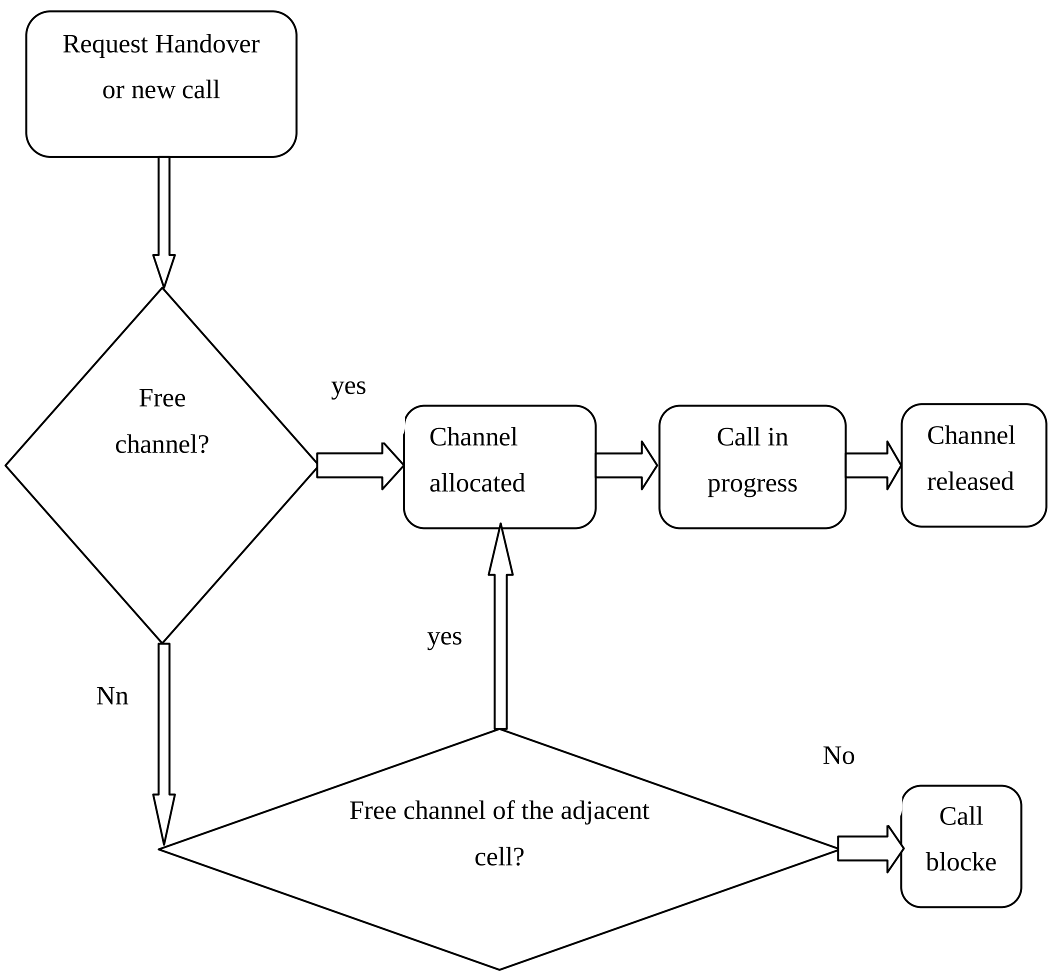


Figure 5. The Blocking Probability of New Calls and Handover According to Traffic (Erlang) for FCA and DCA Priority

7. DCA with Queuing Requests Handover

7.1. Organization Chart



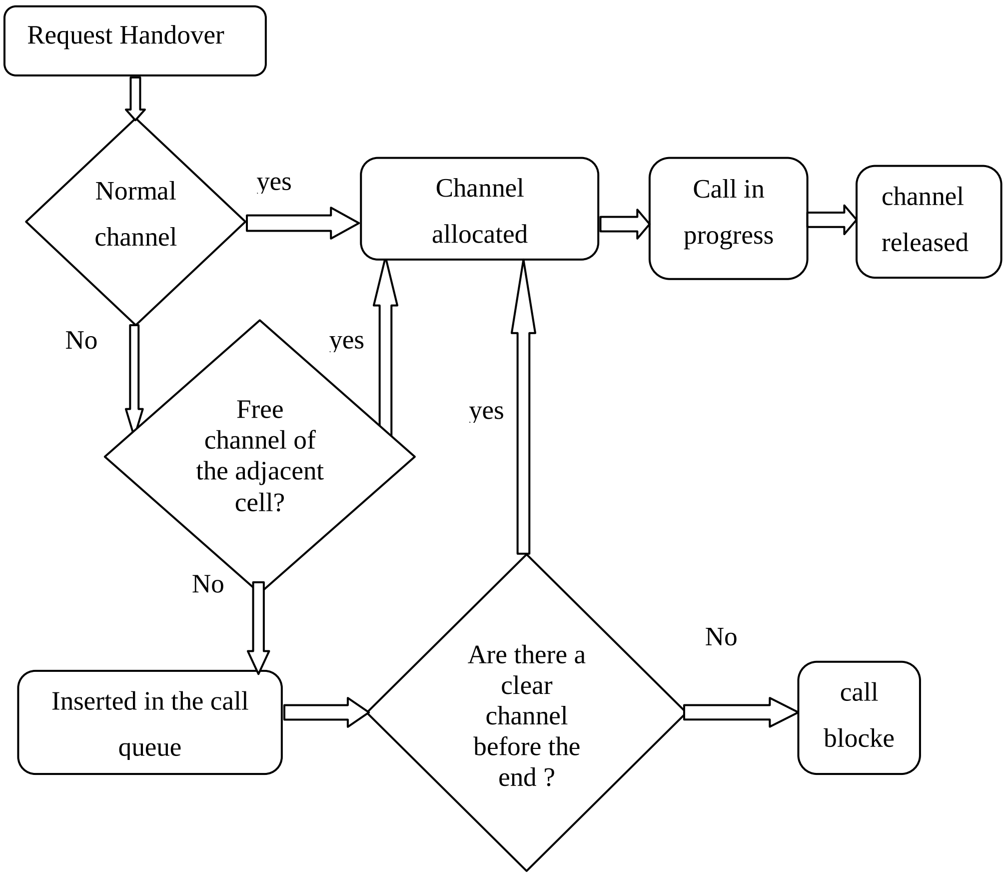


Figure 6. Organization Chart of DCA Technique with Queuing Requests Handover

7.2. The Simulation Results

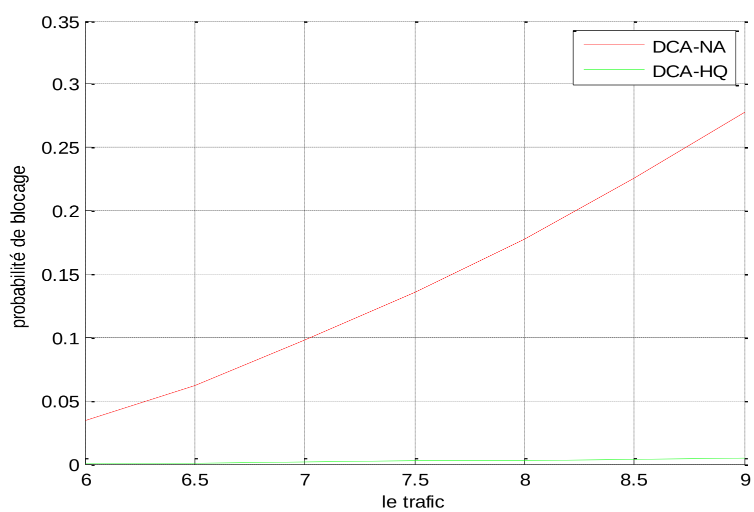


Figure 7. DCA with Queuing Requests Handover

Figure 7 shows the blocking probability of new calls and handover based on traffic to the DCA technique with queuing requests handover.

It is noted that the handover blocking probability decreases when using the technique of dynamic channel allocation with a queue for requests handovers.

Figure 8 shows the comparison between the FCA technique and DCA technique with queuing requests handover based on traffic (Erlang).

The Figure 9 shows the comparison between the FCA technique and DCA technique with queuing requests handover and DCA without priority handover based on traffic (Erlang).

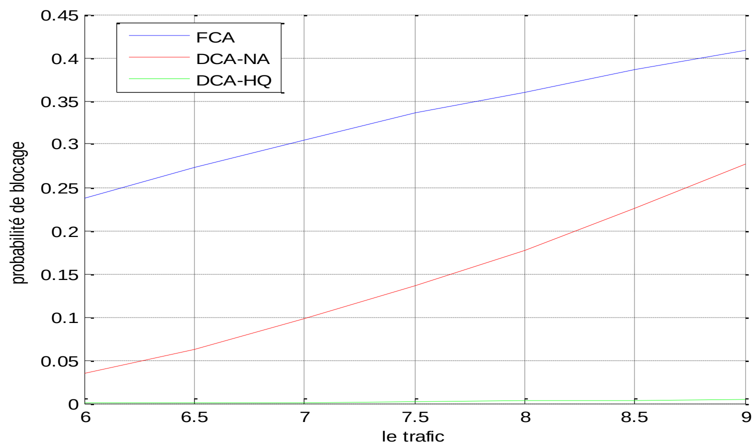


Figure 8. Comparison between FCA and DCA with Queuing Requests Handovers

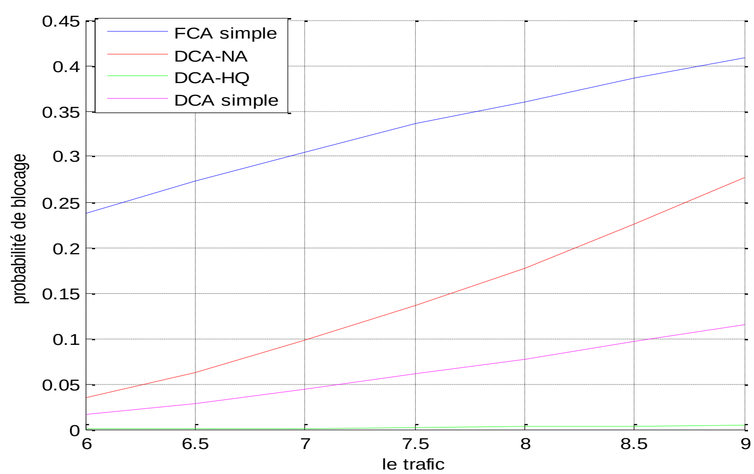


Figure 9. Comparison of Three Techniques FCA, DCA and DCA with no Priority Queuing of Handover Requests

8. Discussion

In this chapter, the performance of the allocation technique was calculated by simulations. In particular, we examined the entire network parallelogram-shaped cell with N cells on each side and the results shown in the graphs were collected only central cells, *i.e.*, those cells with a complete cell disruptor in the network. In previous simulations, we use N = 2.

The technical performance of FCA and DCA is shown in previous Figures in terms of Pb and Ph, respectively, for the cases with and without waiting for a request queue of Handovers. Note that by means of DCA, if handovers are not queued, they have the same priority of service as of newcomers; Therefore, Pb = Ph, and Figure 2 shows a single curve for DCA. Queuing requests handovers leads to considerable loss of Ph and an increase of Pb. Establishing priority handover leads to higher values for the new call blocking.

The simulation of this technique with DCA queuing requests from handovers shows that queuing calls handovers decreases its blocking probability when compared with the DCA technique without priority and FCA.

The Figure 9 shows that the DCA technique with queuing requests Handover gives the best performance for the blocking probability of Handovers

9. Conclusion

In this paper, we are interested in satellite networks in the constellation of low-orbit satellites providing mobile communication. The study of these systems has led us to study the problems and evaluate the performance of constellations considered. The problem we have addressed in this work is the problem of handover (intercell transfer).

The performance of satellite systems has been investigated by several authors to assess the probability of call blocking, and focus on establishing methods to improve call performance during Handovers.

Call blocking due to Handovers can severely reduce system reliability. Another performance measure of interest is the blocking probability of new calls. A new call will be blocked if there will not be enough capacity to carry it. Increasing the blocking of a new call, the rejection of the system decreases. Usually there is an exchange between the new call blocking and call blocking of Handovers. From the point of view of service quality, it is usually preferable to reduce the call blocking Handovers without reducing blocking new calls dramatically.

Our contributions are to compare the behavior of the FCA and some diagrams DCA scheme by a simulation study in Matlab. The study of these mechanisms has been carried out under the common conditions such that the cell structure, the number of channels, and the intensity pattern of the traffic in each cell. DCA patterns showed a significant improvement over the performance of the FCA, namely, lower blocking probabilities for both new calls and handovers.

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